Analysis of Agricultural Biotechnology Firms in the United States with Regard to Product Development and Financial Resources

Honors Thesis

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By
Lori Nickles

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Honors Examination Committee:
David E. Hahn
Thomas L. Sporleder
Carl Zulauf

Project Advisor
Thomas L. Sporleder

Abstract

Agricultural biotechnology is a growing industry that creates many benefits. Through plant and animal science, this industry improves efficiency and reduces costs for agriculture by researching genetics of plants and animals and creating changes in the DNA to produce higher quality, higher production crops and livestock. Biotechnology also helps the agricultural industry by improving food processing, bioremediation, and biomass conversion practices.

This study researches agricultural biotechnology firms in the United States. It reviews revenue, employment, research and development, financing, and products marketed and products in development. This thesis analyzes any possible relationships between the agricultural industry and the biotechnology industry.

The amount of revenue and employees of agricultural biotechnology companies is very high, showing the importance of biotechnology in America. However, no substantial link relates the agricultural industry and biotechnology. Agricultural biotechnology is widely dispersed across the nation and is not dependent on the amount of agriculture in each state. For example, Idaho and Wyoming have no agricultural biotechnology firms while Massachusetts has 36 firms and New Jersey has 33 firms.

The firms' product emphasis varies, but most firms focus on plant input and animal input characteristics, such as herbicide and insect resistance and vaccines, and focus on bioprocessing involving the improvement of food processing. The least amount of product emphasis included plant and animal output characteristics because these are in their early stages of development.

There are no trends between states in regards to the averages of each firm's revenue, employment, and research and development per state. Each state varies substantially in total amounts and average amounts per firm.

Introduction

"Biotechnology is, without a doubt, one of the most precocious of discoveries, quickly moving into the center of biological sciences. It is providing for new products which promise to add much to commerce and industry, including specific biomedical therapies and dramatically improved agricultural practices and products" (National Agricultural Biotechnology Council, 1993, p. 13).

Agricultural biotechnology is the scientific alteration of the genetics of crops, livestock, and food processing to allow for greater productivity and/or production. Agricultural biotechnology includes techniques such as: recombinant DNA, gene transfer, embryo manipulation and transfer, plant regeneration, tissue culture, monoclonal antibodies, and bioprocess engineering (Baumgardt and Marshall, p.3).

Agricultural biotechnology began with Gregor Mendel, who cross-pollinated pea plants to discover the dominant and recessive genes that plants carry. Mendel's research created the foundation for the discovery and analysis of DNA, and, therefore, the advent of genetic engineering (Baumgardt and Marshall, pp. 9-12).

Today, agricultural biotechnology creates tremendous opportunities for American agriculture. In the area of plant science, biotechnology aids crops through increased insect and disease control, new approaches to weed control, improved resistance to environmental stress factors, more efficient use of nutrients, improved product quality, and improvements in plant metabolic characteristics (Baumgardt and Marshall, p.13). In 1998 genetically modified corn, cotton, and soybean crops accounted for 20 to 44 percent of the acreage planted (United States Department of Agriculture). The following table represents some of the biotechnology that is affecting plant science:

PRODUCT	GENETIC MODIFICATION	PURPOSE
tomatoes, peas, peppers, tropical fruit, broccoli, raspberries, melons	controlled ripening	Allow shipping of vine-ripened tomatoes; improve quality, shelf life, food processing
tomatoes, potatoes, corn, lettuce, coffee, cabbage family, apples	insect resistance	Reduce insecticide use
peppers, tomatoes,	fungal resistance	Reduce the fungicide use
potatoes, tomatoes, cantaloupe, squash, cucumbers, corn, oilseed rape (canola), soybeans, grapes	viral resistance	Reduce diseases caused by plant viruses and, since insects carry viruses, reduce insecticide use
soybeans tomatoes, corn, oilseed rape (canola), wheat	herbicide tolerance	Improve weed control
corn, sunflowers, soybeans, and other plants	improved nutrition	Increase the amount of essential amino acids, vitamins or other nutrients
oilseed rape (canola), palm (date, oil or heart)	improved nutrition	Increase the amount of unsaturated oils in the plant by altering the oil-producing pathway
oilseed rape (canola), peanuts	heat stability	Improve processing quality; permit new food uses for healthier oils
coffee	low caffeine content	Naturally decaffeinate
corn, peas	controlled starch	Retain sweetness during entire shelf life

Source: Food Marketing Institute, 2000

Biotechnology in animal science has also created many opportunities. These opportunities include: improved efficiency and quality and improved lactation and growth, reproduction, health, and genetics (Baumgardt and Marshall, p. 16)

Burrus and Thomsen argued that the keys to American success in agriculture include: "decreasing the farmers' input cost per unit of output, increasing the farmers' product yield on a per acre basis and per dollar of invested capital, and increasing the consumers' demand for agricultural products"

(Burrus and Thomsen, p. ii). American farmers are able to achieve these through biotechnology because of improved production and efficiency and reduced costs through less need for herbicides, insecticides, vaccines, etc.

Agricultural biotechnology has many benefits. It helps the environment through less need for chemicals. Biotechnology increases production and, therefore, increases the amount food to support the world's growing population. This technology improves nutrition, quality, and taste, which may help reduce cancer and heart disease. Biotechnology allows for the creation of better drugs and vaccines to promote healthier living around the world. Agricultural biotechnology will, in the future, allow for less need of natural resources. (Council for Biotechnology Information, 2000).

Agricultural biotechnology opens doors for American farmers. Farmers are able to increase their productivity and quality of their products while lowering their costs. As all farmers in America adopt biotechnology products, this increase in quality and production and decrease in costs will allow America's competitiveness in agriculture to increase when compared to other nations around the world. Increased competitiveness will allow American farmers to increase their revenues, which is important given the lackluster performance of commodity prices over the last decade.

Problem Identification and Justification

Although agricultural biotechnology is an increasingly important American industry, little research has been done to discover the product and research development that American biotech firms undertake.

This study will research the United States agricultural technology firms to analyze the products, revenues and expenses, research and development, number of employees, amount in budget, products in development, products marketed, and financing. This analysis will create a better understanding of agricultural biotechnology firms in America today.

Objectives

1) to discover what agricultural biotechnology companies are in America
2) to find what these companies' products are, including new product research and development
3) to determine where these firms are, and if there are any trends in location of agricultural biotechnology
4) to determine the amount of revenues and research and development that these firms undertake
5) to determine the number of employees in each firm, and determine the number of those employees committed to research and development of new products
6) to find any possible correlations between the agricultural biotechnology industry and the agriculture sector of the American economy

Through this research, I hope to learn about biotechnology and the new products developed and soon to be developed. I would like to see correlations between states in the amount of research facilities and the amount of money invested in these firms. I would like to determine if biotechnology research is regional or spread throughout the United States. Biotechnology is a scientific phenomenon that could create drastic changes in the way we live, breathe, and eat in the near future. It is important that Americans are informed about the new technologies, and the new products developed from those technologies, to be able to make knowledgeable purchasing decisions based on quality and safety.

Procedures and Methods

1) Gather Research

Most of the research was gathered online from the Institute of Biotechnology Information through a subscription provided by Dr. Thomas Sporleder of the Ohio State University. The Institute of Biotechnology Information supplies data about companies for each state and for the United States as a whole. Information supplied by this research facility includes: company name, address, state, revenue, revenue for biotechnology, R&D budget, R&D expenditures, number of employees, number of biotech employees, company type, biotech industry classification, technologies used, products in development, products on the market, etc. (Institute of Biotechnology Information).

Information was, also, gathered through FedStats, an online government source for factual statistics for the United States as a whole, regions of the U.S., and the fifty states. The statistics gathered from this source included: jobs per state, percent employment in the agricultural sector per state, total farmland per state, total cropland per state, crop output per state, animal output per state, services and forestry output per state, total agriculture sector output per state, and net farm income per state.

Gross state product (GSP) was gathered through the Bureau of Economic Analysis of the United States government. These statistics were for 1997 GSP for every state.

The gathering of information consumed a great deal of time. Information gathering began in October of 1999. First, I gathered information from the Institute for Biotechnology Information. I realized that some states were not listed on the database. I needed to wait until March, when the database was properly updated, to gather all appropriate information.

2) Analyze Data

Analysis began in November, before I realized that there was missing information. I began to analyze each state's biotechnology firms, studying their financing, revenue, employment, and research and development. All of this information had to be thrown out. Missing information was not the cause of throwing out the data analysis; the cause was due to human error. I analyzed 1286 biotechnology firms that were categorized under "agriculture" and "biotechnology." However, this did not mean that I was studying agricultural biotechnology companies. It meant that I was studying general biotechnology firms and agricultural biotechnology firms.

Upon further research, I discovered that many of the firms categorized as general biotechnology had links to agriculture. Also, the database included other categories of company type that dealt with agriculture (chemical, diagnostics, energy, food, instruments, pharmaceutical, research, veterinary, and waste). I gathered all of this information and began new data analysis.

I began by categorizing all the products in development and products on the market of each firm with over 1400 firms. I categorized these in order to identify the firms with agricultural interests. The categories included: plant genomics, animal genomics, plant input characteristics, plant output characteristics, plant efficiency characteristics, animal input characteristics, animal output characteristics, animal efficiency characteristics, bioprocessing, bioremediation and environmental testing, biomass conversion, and aquaculture. These categories were provided by An Initial Economic Assessment of Agricultural Biotechnology in Ohio. Another category, agriculture for medical purposes, was added. Below gives a description of each category (Sporleder, 1999).

- Plant Genomics: The function, features, and location of genes in plants.

- Animal Genomics: The function, features, and location of genes in animals.
- Plant Input Characteristics: Any biotechnology that results in adding value through influencing the input characteristics of the commercial product or services. Herbicide tolerance or insect resistance are example application technologies in this category. Specifically, Roundup Ready soybeans alter the characteristics of the input (the seed) compared to conventional seed beans. Another example is a genetically modified seed corn that provides the plant protection against disease. As a specific example, NatureGard™ hybrid seed corn by Mycogen offers the plant resistance to the European corn borer.
- Plant Output Characteristics: Any biotechnology that results in adding value through influencing the output characteristics of the commercial product or service. For example, high-lysine corn alters the output characteristics of the commodity that is sold relative to conventional No. 2 yellow corn. Similarly, low linolenic soybean oil possesses enhanced stability, reducing the need for chemical hydrogenation, which ultimately results in reduced transfatty acids in the target processed product. Yet another example is an edible vaccine bred into genetically modified potatoes or bananas, which results in immunity to certain human disease.
- Plant Efficiency Characteristics: Any biotechnology that results in adding value through influencing the efficiency or agronomic characteristics of the commercial product or service. For example, a biotechnology that results in grater yield per acre for a commodity would be categorized here. Included in this broad class are technologies that result in enhanced efficiency in food processing. Genetically modified tomatoes that result in higher yield of solids in the processing plant is another example of altering the commodity (in this case the tomato) for enhanced efficiency in processing. As an additional specific example, Chy MaxTM by Pfizer is a fermentation-derived version of

the enzyme chymosin used in making hard cheeses. This product offers processors advanced fermentation of higher purity, quality, and activity than natural rennet.

- Animal Input Characteristics: Any biotechnology that results in adding value through influencing the input characteristics of the commercial product or service. For example, animal health technologies that may be classified as veterinary vaccines or biologics are in this category. A transgenic animal that is resistant to disease or experiences an improved health status (e.g. pigs resistant to scours).
- Animal Output Characteristics: Any biotechnology that results in adding value through influencing the output characteristics of the commercial product or service. Genetically modified animals to produce an enhanced quality of meat (e.g. less fat per pound of lean) would be an example.
- Animal Efficiency Characteristics: Any biotechnology that results in adding value through influencing the efficiency or yield characteristics of the commercial product or service. Reproduction technologies such as superovulation and in vitro fertilization would be examples within this category. For example, growth promotants such as bovine somatotropin or swine somatotropin (bST and pST, respectively) represent early biotechnologies that result in greater efficiency in the sense of more output per unit of input. For dairy operations, bST results in increased output of milk per cow. Similarly, transgenic animals that result in greater meat per pound of feed fed, or other efficiency criteria, would also be part of this category.
- Bioprocessing: Often popularly called "pharming," this is a broad class of technologies that use microbial, plant, or animal cells for the production of chemical compounds. Bioprocessing exploits several biological phenomena ranging from fermentation to the production of enzymes, amino acids, and

biocatalysts. Using bovines as bioreactors to harvest body fluids of potential value in the human health market is an example of bioprocessing. Also included here are process monitoring and control methods developed specifically for bioprocessing. The monitoring and control of manufacturing processes requires information feedback from every critical step in the bioprocess. Examples are biosensors that operate automatically and are environmentally benign during the manufacturing processes or allow the detection, monitoring, and control of food additives, food safety factors, and bioremediation technologies. Bioprocessing potentially influences industries ranging from food production, pharmaceutical, chemical and even mining industries.

- Bioremediation and Environmental Testing: This area is a class of applications that endeavor to use biotechnology to assess and improve the well-being of ecosystems, transform pollutants into benign substances, generate biodegradable materials from renewable sources, and/or develop environmentally safe manufacturing and disposal processes. Different types of organisms can be bioremediation agents. For example, plants can be used to concentrate pollutants. More common, however, is bioremediation by microorganisms. Microorganisms (primarily bacteria and fungi) naturally recycle. They are capable of transforming natural and synthetic chemicals into sources of energy and raw materials for their own growth. Bioremediation through microorganisms involves replacing or supplementing chemical processes with biological processes that may be lower in costs and more environmentally benign.
- Biomass Conversion: Biomass uses biological processes to produce organic polymeric material, such as lignin, starches, cellulose, and oil. Plants and algae are the primary stock for biomass conversion. Possible, but less

important, additional sources of biomass stock include food processing waste, waste paper, and municipal solid waste.

- Aquaculture: Any biotechnology that results in adding value through influencing the commercial products from marine animals. Genetically modified fish may enhance the human food supply.
- Agriculture for Medical Purposes: Any biotechnology that uses plants and/or animals in order to aid human health. An example of this category would include animal organs implanted into humans to increase human survival.

It should be noted that most firms were listed in more than one category because these firms develop and market many different products which fall into different categories.

Once all products were categorized, I studied the "biotechnology industries" category on the Institute for Biotechnology Information to determine that all firms were properly categorized. I, then, removed all biotechnology firms with no emphasis on agriculture.

The following categories were all focused on during the data analysis: number of companies per state, state, employees per state, biotech employees per state, financing (private or public) per state, revenue of biotech firms per state, biotech revenue of biotech firms per state, research and development budget of biotech firms per state, research and development biotech budget of biotech firms per state, number of biotech firms in the thirteen product categories referred to above, average employees per firm per state, average biotech employees per firm per state, average revenue per firm per state, average biotech revenue per firm per state, average R&D per firm per state, average R&D biotech per firm per state, revenue per employee per state, R&D per dollar of revenue, percent biotech employees, percent biotech revenue, percent biotech R&D (all obtained from the Institute of Biotechnology Information, 2000).

Number of jobs per state (1997), percent agricultural jobs per state (1996), total land per state (1997), farmland per state (1997), percent farmland of total land per state (1997), cropland per state (1997), percent cropland of farmland per state (1997), crop output per state (1998), animal output per state (1998), services and forestry output per state (1998), total output per state (1998), net farm income (1998) were obtained from FedStats and focused on. Gross State Product (abbreviated GSP, 1997) was found at the Bureau of Economic Analysis and was integrated into the research.

The following calculations were made based upon the statistics listed above: total agricultural output per state compared to total revenue per state, GSP compared to revenue per state, GSP compared to net farm income per state, number of jobs per state compared to employees of biotech firms per state, number of jobs per state compared to biotech employees of biotech firms per state, and employees of biotech firms compared to biotech employees of biotech firms per state. The calculations included: adjusted R squared and standard error as well as correlation and standard deviation. These calculations were made in order to see possible relationships between the two features compared.

3) Draw Conclusions Based on Analysis

The results of the data analysis were derived from the information and calculations. The results of correlations and adjusted R squared were expected to be low, and standard deviation and standard error were expected to be high. In other words, no relationships were expected between any features compared. Microsoft Excel was the statistical software used to determine the calculations. Tables and charts are supplied in the Appendix of this thesis to aid in the understanding of the trends of the data analysis. The Results/Discussion section will analyze these results.

Results/Discussion

A total of 573 biotechnology firms are agriculturally related. These firms are located in 43 states as well as Washington D.C.. 359 of these firms are funded privately while 174 are funded publicly. These firms collectively have almost one million employees, $260 billion in revenue, and $14 billion budgeted for R&D (refer to Table 1 in Appendix). These figures are astounding and show the importance of agricultural biotechnology in this country.

However, when looking at the dispersion of agricultural biotech firms, there is no prominent central location for this biotechnology research. It seems to be widely spread across the United States (refer to United States map in Appendix). California has the most agricultural biotechnology firms with 81. However, most states have under twenty firms (refer to Table 1 in Appendix).

There are almost double the amount of private agricultural biotechnology firms as there are public firms (refer to Table 1 in Appendix). This represents a great deal of independent research used to manufacture specific products with detailed features. There seems to be no trends depending on location of the firms and their type of financing.

It is surprising to see that California, with almost two and a half times more firms than New Jersey, has five times less revenue than New Jersey. This may partially be due to firms not reporting their revenues to the Institute for Biotechnology Information. Also, these firms may not have revenues because they are new to the market and have no products to sell. They may need tremendous research and development before products can be developed and marketed. California does have a greater biotech R&D budget compared to the other states (refer to Table 1 in Appendix).

Animal input characteristics and plant input characteristics as well as bioprocessing seem to be the focus of many biotech firms (refer to Table 2 in

Appendix). Many companies are developing and marketing seeds that are more tolerant to the conditions including insect and weed resistant plants in order to increase productivity and efficiency on the farm. Also, many firms focus on veterinary care, vaccines, and health supplies for livestock to promote a healthier and more productive herd. Bioprocessing is common among agricultural biotechnology firms because it deals with ways to improve foods through different processing methods.

Plant and animal output characteristics obtain much less emphasis because these areas deal with new ideas in which firms are just beginning to become aware of and promote.

There tends to be extensive fluctuation in the averages calculated. Average employees per firm per state, average biotech employees per firm per state, average revenue per firm per state, average biotech revenue per firm per state, average R&D per firm per state, and average biotech R&D per firm per state have no consistency between states (refer to Table 3 and charts in Appendix). This finding reveals that sizes of agricultural biotechnology firms vary from state to state in no particular fashion.

Also, there are many fluctuations in the percent of average biotech employees to average employees, the percent of average biotech revenue to average revenue, and the percent of average biotech R&D to average R&D (refer to Table 3 in Appendix). Agricultural biotechnology companies vary from state to state as well as within each state. These variations create the fluctuations.

The following table represents some data analysis to determine if relationships exist among the variables:

	Adjusted R^2	Standard Error	Correlation	Standard Deviation
Total Output, Revenue	-0.02116887	14278.4563	0.04232385	4125597.6
GSP, Revenue	-0.01838757	14258.9983	-0.07277264	160997.4
GSP,Net Farm Income	0.27635920	863444.2301	0.54146843	825964.5
Jobs, Employees	0.10796036	49874.9735	0.35875545	2895531.8
Jobs, Biotech Employees	0.49720787	315.0419	0.71337277	2901837.9

Total output compared to total revenue per state showed no signs of a relationship (refer to Table 1 and Table 4 in Appendix). The adjusted R^2 and correlation are very low, and the standard error and standard deviation are very high. There is wide scatter among these points (refer to Total Output vs. Revenue chart in Appendix). This proves no relationship exists between agricultural biotechnology companies' sales and total agricultural output.

Gross State Product when compared to total revenue per state revealed no relationship (refer to Table 1 and Table 4 in Appendix). The adjusted R^2 and the correlation were both very low, and, actually, negative. The standard error and standard deviation were both very high. This truly represents no relationship among these two variables (refer to GSP vs. Revenue chart in Appendix).

Gross State Product and Net Farm Income have a small adjusted R^2 and correlation. However, they have a high standard error and standard deviation. No true relationship exists between these two variables (refer to Table 4 and GSP vs. Farm Net Income chart in Appendix). The chart in the Appendix shows wide dispersion of points revealing little, if any, relationship.

Jobs per state and total employees per state also show few signs of relationship (refer to Table 1 and Table 4 in Appendix). These have a low correlation and R^2 and a high standard deviation and standard error. The dispersion of points follows a slight pattern besides several exceptions (refer to Jobs vs. Employees chart in Appendix). This reveals a small possibility of a relationship.

Jobs per state and total biotech employees per state has a strong correlation and adjusted R^2. They do have a large standard error and standard deviation, but the correlation is surprising. Since the Jobs vs. Employees had a low correlation, this comparison is expected to have a low correlation. I feel that this is questionable and little relationship between the two variables exist. The dispersion of points is mainly found at the minimum points on the graph (refer to Table 1 and Table 4 and Jobs vs. Biotechnology Employees chart in Appendix). This, also, causes the relationship to be questionable.

No relationship is found with total employees and total biotech employees. They have a low adjusted R^2 and correlation as well as a high standard error and standard deviation. The dispersion of points on the graph present a varied scatter (refer to Table 1 and Employees vs. Biotech Employees chart in Appendix).

Conclusions

This thesis revealed no relationship between agriculture and agricultural biotechnology firms. These firms tend to locate in non-specific areas and are not dependent upon the agricultural industry of the state.

Products of firms vary across and within states. There is no consistency in the location to produce specific products.

Agricultural biotechnology is an increasingly important factor in the United States agricultural industry. The amount of revenue of these firms and the number of workers they employ reveal this importance.

Agricultural biotechnology will have a tremendous impact on the future of agriculture, and the statistics studied in this thesis will grow considerably. Tremendous potential awaits this new technology. We will see bushels per acre and gains per day of livestock increase substantially. Food will be processed more efficiently and abundantly. Environmental conservation will increase because of bioremediation practices. These opportunities will allow our diverse world to prosper for many years to come.

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Appendix

Map: Agricultural Biotechnology Firms per State

Table 1: Basic Overview of States' Biotechnology Firms

Table 2: Firms per State with Products Developed and Marketed Categorized

Table 3: Calculations of Biotech Firms per State

Table 4: General Data for Each State

Chart: Average Employees per State

Chart: Average Biotech Employees per State

Chart: Average Revenue per Firm per State

Chart: Average Biotech Revenue per Firm per State

Chart: Average R&D per Firm per State

Chart: Average Biotech R&D per Firm per State

Chart: Total Output vs. Revenue

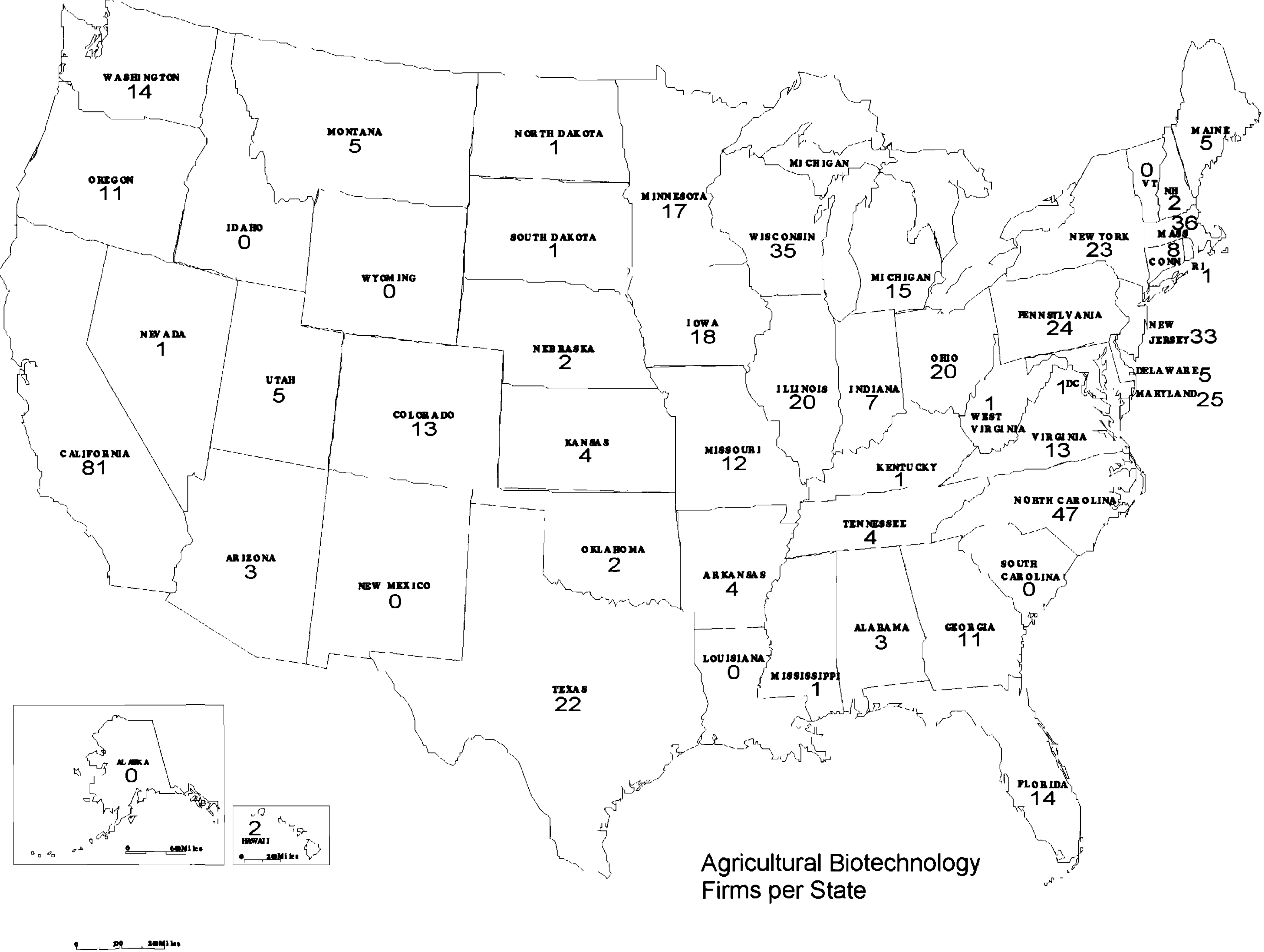
Chart: GSP vs. Revenue

Chart: GSP vs. Farm Net Income

Chart: Jobs vs. Employees

Chart: Jobs vs. Biotechnology Employees

Chart: Employees vs. Biotech Employees



Agricultural Biotechnology
Firms per State

TABLE 1. BASIC OVERVIEW OF STATES' BIOTECHNOLOGY FIRMS

COMPANIES	STATE	EMPLOYEES	BTEMPLOYEE	FINANCE TYPE	REVENUE (millions $)	REVBT_ (millions $)	R_DBUDGET (millions $)	R_DBT_ (millions $)
3	AL	220.0	20.0	3V	2.00000	124.000	0.22000	199.00
4	AR	60.0	5.0	3V,1P	0.000	185.000	0.000	290.000
3	AZ	35.0	5.0	3V	103.00000	100.00000	60.10000	10.0
81	CA	48707.0	2094.0	50V,25P	14331.04400	1448.00	644.95500	1739.0
13	CO	1255.0	253.0	5V,7P	111.03200	100.00000	67.69800	199.00000
8	CT	7689.0	125.0	5V,3P	958.58000	0.00000	87.85000	0.00000
1	DC	15.0	0.0	1V	0.00000	0.000	0.000	0.000
5	DE	597.0	78.0	2V,2P	16.72500	100.00000	12.92200	100.00000
14	FL	321.0	4.0	10V,4P	58.98600	378.00000	8.49100	444.00000
11	GA	893.0	240.0	7V,1P	24.25900	149.00000	11.90500	130.00000
2	HI	126.0	29.0	1V,1P	7.63000	0.00000	0.68000	0.00000
18	IA	6072.0	158.0	13V,1P	18.37100	191.00000	115.51700	439.00000
20	IL	99523.0	509.0	10V,4P	31355.83000	500.00000	1389.22500	519.00000
7	IN	1887.0	2.0	6V,1P	1510.00000	200.00000	120.00200	200.00000
4	KS	1885.0	0.0	2V,1P	108.00000	30.00000	0.30000	100.00000
1	KY	150.0	0.0	1V	50.00000	100.00000	5.00000	100.00000
36	MA	7265.0	731.0	24V,11P	994.19400	347.00000	153.00800	610.00000
25	MD	3453.0	157.0	18V,7P	466.57800	559.00000	47.73700	854.00000
5	ME	2095.0	65.0	3V,2P	362.69400	100.00000	38.17000	20.00000
15	MI	41680.0	502.0	11V,4P	36095.50000	400.00000	1682.61000	324.00000
17	MN	83429.0	108.0	9V,6P	545.34600	250.00000	5.98600	182.00000
12	MO	84419.0	2.0	5V,6P	27636.08000	215.00000	1267.65000	120.00000
1	MS	600.0	0.0	1P	0.00000	0.000	0.00000	0
5	MT	158.0	126.0	4V,1P	7.22000	200.00000	10.27000	200.00000
47	NC	4369.0	1576.0	31V,11P	490.03000	2424.00	159.21000	1529.00
1	ND	70.0	0.0	1V	2.50000	0.00000	0.00000	0.00000
2	NE	200.0	0.0	2V	0.00000	0.00000	0.00000	0.00000
2	NH	526.0	0.0	1V,1P	0.62800	0.00000	0.00000	0.00000
33	NJ	309184.0	749.0	9V,24P	75402.84600	40.00000	6033.62000	161.00000
1	NV	923.0	0.0	1P	205.12000	0.00000	2.27000	0.00000
23	NY	98789.0	1346.0	11V,11P	22600.78500	495.00000	224.30600	497.00000
20	OH	42533.0	163.0	14V,6P	17062.70500	364.00000	1600.33000	502.00000
2	OK	14.0	9.0	2V	0.00000	99.00000	0.00000	99.00000
11	OR	427.0	48.0	6V,5P	53.48800	130.00000	15.06100	130.00000
24	PA	65209.0	347.0	13V,7P	15904.51600	350.00000	266.50000	477.00000
1	RI	12.0	0.0	1P	1.07000	0.00000	0.91000	0.00000
1	SD	200.0	30.0	1V	15.00000	4.00000	14.00000	5.00000
4	TN	99.0	85.0	4V	11.05000	50.00000	12.36000	149.00000
22	TX	35888.0	106.0	15V,7P	3249.11000	266.00000	31.50600	263.00000
5	UT	636.0	17.0	4V,1P	9.29000	15.00000	19.82000	198.00000
13	VA	305.0	41.0	13V	5.05000	390.00000	5.15000	560.00000
14	WA	36211.0	6.0	9V,5P	10888.52000	393.00000	84.05300	348.00000
35	WI	5362.0	323.0	26V,5P	73.32200	634.00000	108.89600	689.00000
1	WV	7.0	0.0	1V	0.00000	0.00000	0.00000	0.00000
573	Total	993498	10059	359V,174P	260738	11330	14308	12386

COMPANIES: number of companies per state
STATE: state
EMPLOYEES: number of employees of biotech firms per state
BTEMPLOYEE: number of biotech employees of biotech firms per state
FINANCE TYPE: how company is financed, V=private, P=public
REVENUE: amount of revenue of biotech firms per state
REVBT_: amount of biotech revenue of biotech firms per state
R_DBUDGET: amount budgeted for R&D for biotech firms per state
R_DBT_: amount budgeted for biotech R&D for biotech firms per state
*Note: all information not available for all firms; numbers gathered based on information given
Source: Institute for Biotechnology Information, 2000

TABLE 2. FIRMS PER STATE WITH PRODUCTS DEVELOPED AND MARKETED CATEGORIZED

STATE	Plant Genomics	Animal Genomics	Plant Input	Plant Output	Plant Efficiency	Animal Input	Animal Output	Animal Efficiency	Bioprocessing	Bioremediation	Biomass	Aquaculture	Medical
AL		1							1				1
AR									3		1		2
AZ			1			1				1		1	
CA	9	11	14	4	8	23			19	9	5	3	18
CO			4			2	1		3	3	3	2	1
CT	1		2		2	4			2	1	1	2	1
DC						1							
DE			2	1	1				2	1	1		
FL	1	1			1	5		1	4	5	1	3	4
GA						7		1		2		1	1
HI			2						1			1	
IA		3	8		2	10			4	2			2
IL			5			8			13	3	2		1
IN	1		3			2			1	1		1	2
KS						4							
KY						1			1	1	1	1	
MA	1	4	4			8			13	4	2	3	8
MD		1	3			9			5	7		4	9
ME						4			1	1		1	1
MI	1		4		2	3			3	6	1	1	
MN			6			5			2	5	1		2
MO	1	1	5			8		1	5	2			
MS			1										
MT		2	1			2		1	1	1	2		
NC	3		15		1	17		2	10	9	2	1	1
ND	1		1							1			
NE						1				1			
NH									1				1
NJ	2	1	10	2		10			10	7	1	4	1
NV						1							
NY	2		6			12			6	4	1	1	
OH			5	1		6			8	6	1	1	3
OK						1					1		
OR	1		2		1	3			2	6	1	1	1
PA	3	3	6	2		8			7	5	3	3	1
RI									1				
SD						1							
TN			1			3				1			
TX	2	3	3			10			3	6	1	2	3
UT	1		1			1				3	2	1	1
VA	1	1	4			4			6	4		2	2
WA	1		6			4			6	3	2	3	3
WI	5	4	12	2	1	7			17	6	5		2
WV						1							
Total	37	36	137	12	19	197	1	6	161	117	41	43	72

*Note: all numbers equal the total number of firms per state that have an emphasis in the specific product categorization

Source: Institute for Biotechnology Information, 2000

TABLE 3. CALCULATIONS OF BIOTECH FIRMS PER STATE

STATE	Average Employees	Average BTEmp	Average Revenue	Average Revbt	Average RD	Average RDBT	Revenue per Emp	RD per Revenue	%BTEmp	%BTRev	%BTRD
AL	73.33333	20	2	62	0.22	99.5	27272.73	0.11	0.272727	31	452.2727
AR	20	5		92.5		96.66666			0.25		
AZ	11.66666	5	51.5	100	30.05	10	4414286	0.583495	0.428571	1.941748	0.332779
CA	616.5443	74.78571	358.2761	39.13514	16.9725	72.45833	581103.6	0.047372	0.121298	0.109232	4.269161
CO	96.53846	50.6	13.879	100	8.46225	99.5	143766.5	0.609716	0.524143	7.20513	11.7581
CT	961.125	125	319.5266		29.28333		332450.7	0.091645	0.130056		
DC	15										
DE	149.25	26	8.3625	100	4.307333	100	56030.15	0.515077	0.174204	11.95815	23.21622
FL	24.69230	4	7.37325	94.5	1.213	88.8	298605.1	0.164513	0.161994	12.8166	73.20692
GA	81.18181	80	6.06475	74.5	2.97625	65	74705.77	0.490745	0.985442	12.2841	21.83956
HI	63	29	7.63		0.68		121111.1	0.089121	0.460317		
IA	337.3333	31.60000	3.06183	63.66667	19.25283	48.77778	9076.581	6.288008	0.093676	20.79364	2.533538
IL	4976.15	84.83333	2850.53	83.33333	138.9225	64.875	572838.4	0.048735	0.017048	0.029234	0.466987
IN	269.5714	2	755	100	60.001	100	2800742	0.079471	0.007419	0.13245	1.666639
KS	471.25		54	30	0.3	100	114588.9	0.005555		0.555556	333.3333
KY	150	0	50	100	5	100	333333.3	0.1	0	2	20
MA	207.5714	60.91666	55.233	69.4	8.500444	87.14285	266091.5	0.153901	0.293473	1.256495	10.25156
MD	143.875	15.7	33.327	79.85714	3.409785	85.4	231638.6	0.102313	0.109123	2.39617	25.04556
ME	419	21.66666	120.898	100	19.085	20	288539.4	0.157860	0.05171	0.827144	1.047943
MI	2977.142	83.66666	5156.5	80	210.3262	64.8	1732030	0.040788	0.028103	0.015514	0.308093
MN	5214.312	21.6	68.16825	50	1.1972	30.33333	13073.3	0.017562	0.004142	0.733479	25.3369
MO	7034.916	2	4606.013	71.66667	316.9125	60	654736	0.068804	0.000284	0.015559	0.189327
MS	600		192				320000				
MT	31.6	42	2.406666	100	3.423333	100	76160.34	1.422437	1.329114	41.55125	29.2113
NC	97.08888	43.77777	25.79105	89.77778	7.9605	84.94444	265643.7	0.308653	0.450904	3.480966	10.67074
ND	70		2.5				35714.29				
NE	100										
NH	263		0.628		0		2387.833	0			
NJ	9662	68.09090	3770.142	20	317.5589	53.66666	390203.1	0.084229	0.007047	0.005305	0.168997
NV	923	0	205.12	0	2.27	0	222231.9	0.011066	0	0	0
NY	4295.173	122.3636	1506.719	82.5	16.02185	62.125	350793.5	0.010633	0.028489	0.054755	3.877516
OH	2362.944	27.16666	2132.838	60.66667	266.7216	62.75	902618.8	0.125054	0.011497	0.028444	0.235264
OK	7	9		99		99			1.285714		
OR	38.81818	9.6	7.641142	65	2.151571	65	196844.4	0.281577	0.247307	8.506581	30.21048
PA	2835.173	57.83333	1445.865	70	29.61111	68.14285	509974	0.020479	0.020399	0.048414	2.30126
RI	12		1.07		0.91		89166.67	0.850467			
SD	200	30	15	4	14	5	75000	0.933333	0.15	0.266667	0.357143
TN	24.75000	42.50000	2.76250	50.00000	6.18000	74.50000	111616.2	2.237104	1.717172	18.09955	12.05502
TX	1631.272	26.5	270.7591	53.2	2.864181	52.6	165980.3	0.010578	0.016245	0.196485	18.36476
UT	127.2000	17.00000	4.64500	15.00000	6.60667	99.00000	36517.3	1.422317	0.133648	3.229279	14.98486
VA	23.46153	8.2	1.01	65	1.03	93.33333	43049.18	1.019801	0.349508	64.35644	90.61489
WA	2789.846	5.666666	991.1998	98.83333	8.393	76.33333	355288.3	0.008467	0.002031	0.099711	9.094881
WI	162.4848	35.88888	12.22033	79.25	18.14933	76.55555	75209.06	1.485174	0.220875	6.485093	4.218092
WV	7										

Average Employees: Average number of employees per firm per state
Average BTEmp: Average number of biotech employees per firm per state
Average Revenue: Average revenue per firm per state
Average Revbt: Average biotech revenue per firm per state
Average RD: Average R&D per firm per state
Average RDBT: Average biotech R&D per firm per state

TABLE 3. CALCULATIONS OF BIOTECH FIRMS PER STATE, continued

Revenue per Emp: Amount of revenue per employee per state (Average revenue/Average employees)
RD per Revenue: Amount of R&D per employee per state (Average R&D/Average employees)
%BTEmp: Percent of biotech employees compared to employees (100*Average BTEmp/Average employees)
%BTRD: Percent of biotech R&D compared to R&D (100*Average RDBT/Average RD)
*Note: all information not available for all firms; numbers gathered based on information given
Source: Institute for Biotechnology Information, 2000

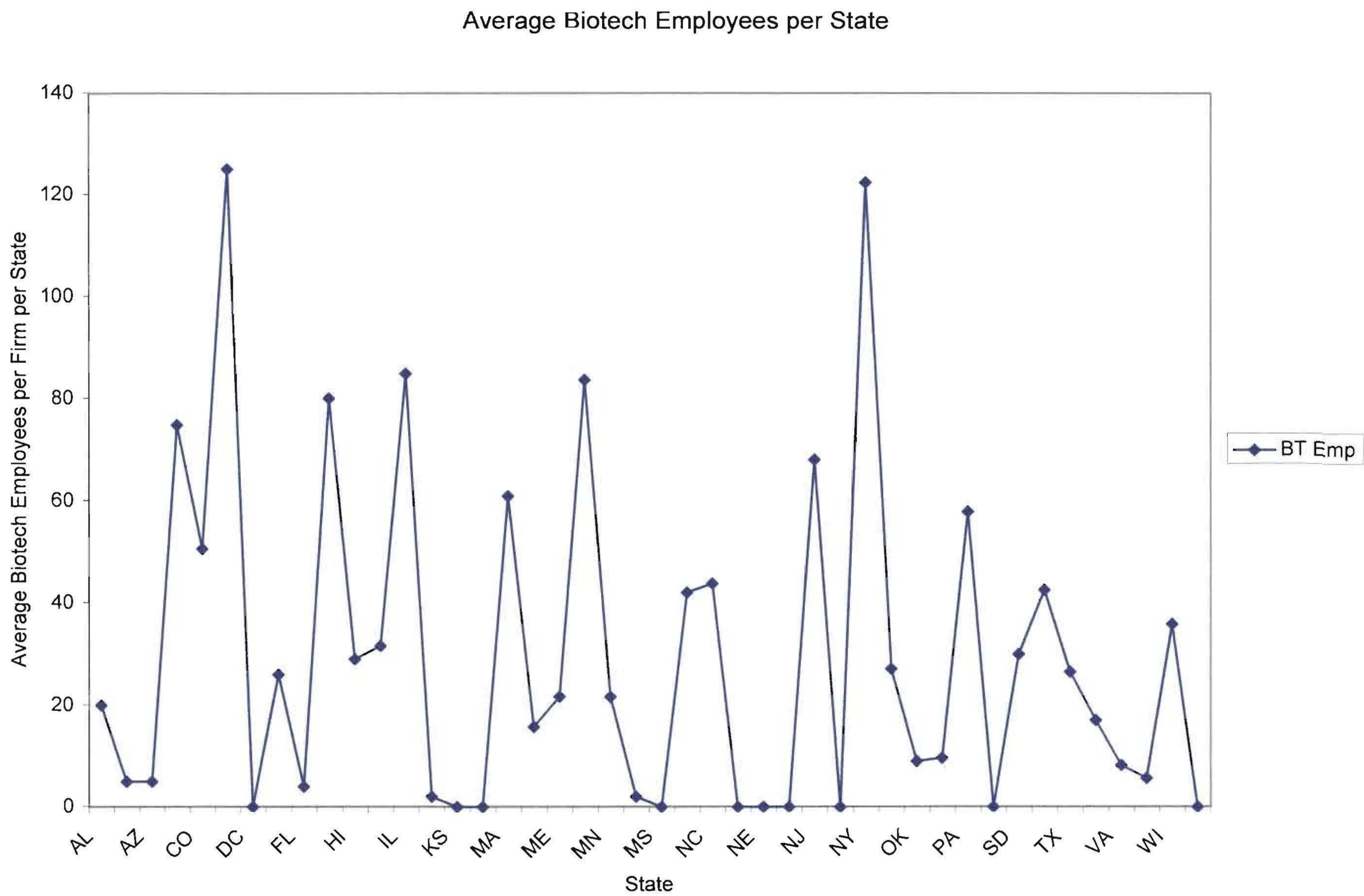
TABLE 4. GENERAL DATA FOR EACH STATE

STATE	Jobs	%ag jobs	Total land	Farmland	%farm/total	Cropland	%crop/farm	Crop output	Animal output	Serv/forest output	Total output	Net farm income	GSP
AL	2325305	18.6	32.5	8.7	26.8	4.2	48.2	668650	2568856	788753	4026259	1209086	103109
AR	1404609	20.5	33.3	14.4	43.1	10.1	70.0	2030191	3258444	634166	5922802	1594954	58479
AZ	2406990	13.2	72.7	26.9	36.9	1.3	4.8	1347830	937631	207735	2493196	700203	121239
CA	17,584,877	14.4	99.8	27.7	27.7	10.8	39.0	17,403,988	6,934,786	1,515,322	25,854,096	5,366,042	1033016
CO	2,551,157	14.3	66.4	32.6	49.2	10.5	32.2	1,515,554	2,794,526	569,504	4,879,585	759,723	126084
CT	1,987,022	11	3.1	0.4	11.6	0.2	50.4	278,448	224,780	62,498	565,726	129,229	134565
DC	712,199	5.8	0	0	0.0	0	0.0	0	0	0	0	0	52372
DE	451,587	13.3	1.3	0.6	46.3	0.5	84.0	164,142	610,139	102,173	876,454	118,055	31585
FL	7,769,775	14.6	34.6	10.5	30.3	3.6	34.8	5,343,106	1,372,230	313,812	7,029,148	2,225,846	52372
GA	4,363,074	17.1	37.1	10.7	28.8	5.4	50.3	1,957,608	3,410,094	773,804	6,141,507	1,900,804	380607
HI	741,493	16	4.1	1.4	35.1	0.3	20.3	418,337	89,172	34,971	542,480	34,157	229473
IA	1,855,872	22.9	35.8	31.2	87.2	26.8	86.1	6,339,120	4,811,820	990,611	12,141,552	2,277,273	161701
IL	7,098,036	13.5	35.6	27.2	76.5	23.9	87.9	6,449,458	1,583,231	736,780	8,769,469	1,483,681	29149
IN	3,507,560	15.3	23	15.1	65.8	12.8	85.0	3,343,604	1,664,703	624,963	5,633,271	801,602	393532
KS	1,685,028	18.9	52.4	46.1	88.0	30	65.1	3,256,422	4,549,830	855,702	8,661,954	1,496,048	80479
KY	2,188,577	19.9	25.4	13.3	52.4	8.5	64.1	1,704,298	2,115,138	639,357	4,458,793	1,313,038	71737
MA	3,923,056	12.3	5	0.5	10.3	0.2	43.1	379,305	109,451	68,785	557,541	130,282	153797
MD	2,906,947	12.2	6.2	2.2	34.7	1.6	74.9	576,752	945,601	254,527	1,776,881	309,508	30156
ME	747,075	16.7	19.8	1.2	6.1	0.5	44.6	227,488	280,724	49,273	557,485	62,700	124350
MI	5,386,527	14.1	36.4	9.9	27.2	7.9	79.9	2,115,449	1,337,831	448,835	3,902,115	308,371	221009
MN	3,166,319	15.7	51	26	51.0	21.5	82.7	4,166,935	3,771,990	852,191	8,791,116	1,260,353	272607
MO	3,351,820	16.6	44.1	28.8	65.4	19.2	66.7	2,173,765	2,452,447	766,450	5,392,662	763,110	58314
MS	1,425,691	19.2	30	10.1	33.7	5.9	58.7	1,166,383	2,160,568	507,976	3,834,926	926,689	149394
MT	534,091	19.3	93	58.6	63.0	17.6	30.1	910,345	871,220	302,304	2,083,869	355,137	152100
NC	4,612,376	19.1	31.2	9.1	29.3	5.6	29.3	3,360,359	3,942,411	1,627,021	8,929,791	2,361,078	651652
ND	441,421	23.2	44.2	39.4	89.1	27	68.7	2,702,460	623,324	337,607	3,663,392	745,510	218888
NE	1,145,953	22	49.2	45.5	92.5	22.1	48.5	3,927,529	5,068,362	780,997	9,776,889	1,758,910	19160
NH	735,959	13.5	5.7	0.4	7.2	0.1	32.0	78,738	72,729	24,160	175,628	11,881	57407
NJ	4,494,373	11.9	4.7	0.8	17.6	0.6	71.5	588,973	174,072	112,573	875,619	117,366	38106
NV	1,089,522	10.8	70.3	6.4	9.1	0.8	13.2	145,040	195,447	39,159	379,646	47,148	48812
NY	9,908,048	12.1	30.2	7.3	24.0	4.7	65.1	1,028,438	2,077,765	291,578	3,397,781	447,430	45242
OH	6,596,769	14.1	26.2	14.1	53.8	11.3	80.4	3,125,197	1,816,740	849,568	5,791,504	1,298,533	15786
OK	1,888,739	17.2	44	33.2	75.6	14.8	44.7	987,617	2,761,595	587,388	4,336,601	900,541	320506
OR	2,000,888	18	61.4	17.4	28.4	5.3	30.3	2,339,208	772,706	685,402	3,797,316	515,110	76642
PA	6,693,841	14.2	28.7	7.2	25.0	5	70.2	1,265,909	2,914,870	505,181	4,685,961	662,070	98367
RI	561,073	13.2	0.7	0.1	8.3	0	46.3	55,817	9,148	8,962	73,926	24,218	339940
SD	499,301	22.7	48.6	44.4	91.3	19.4	43.6	2,146,055	1,667,038	394,416	4,207,509	1,158,285	93259
TN	3,285,827	17.4	26.4	11.1	42.2	7.1	63.6	1,143,935	1,004,205	564,318	2,712,458	343,267	20186
TX	11,238,887	15	167.6	131.3	78.3	37.7	28.7	4,373,727	7,969,411	2,370,302	14,713,439	3,125,087	146999
UT	1,282,500	13.3	52.6	12	22.9	2.1	17.2	245,254	734,350	145,932	1,125,536	218,757	601643
VA	4,123,480	14.4	24.9	8.2	33.0	4.3	52.5	786,116	1,571,086	442,619	2,799,822	496,162	15214
WA	3,363,268	16.4	42.6	15.2	35.6	7.9	52.1	3,531,283	1,695,453	769,091	5,995,826	1,050,467	211331
WI	3,268,072	17.6	34.8	14.9	42.9	10.4	69.5	1,695,168	4,425,655	691,896	6,812,720	908,453	147325
WV	864,397	14.8	15.4	3.5	22.4	1.3	38.7	69,059	340,032	120,180	529,270	34,884	38228

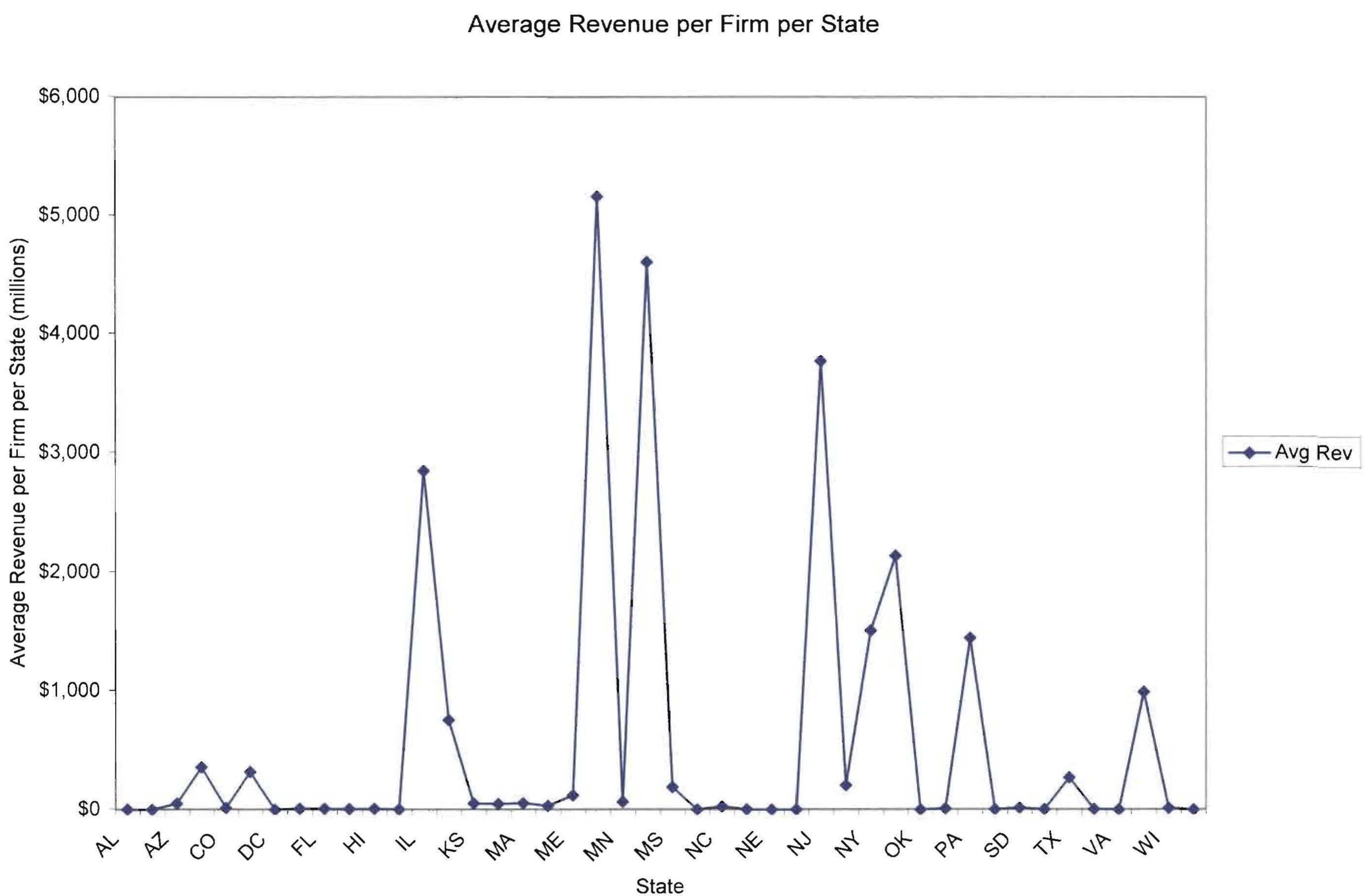
Jobs: total jobs per state
%ag jobs: percent of agricultural jobs per state
Total land: total land area per state, in millions of acres
Farmland: total farmland per state, in millions of acres
%farmland: percent of farmland to total land
Cropland: total cropland per state, in millions of acres

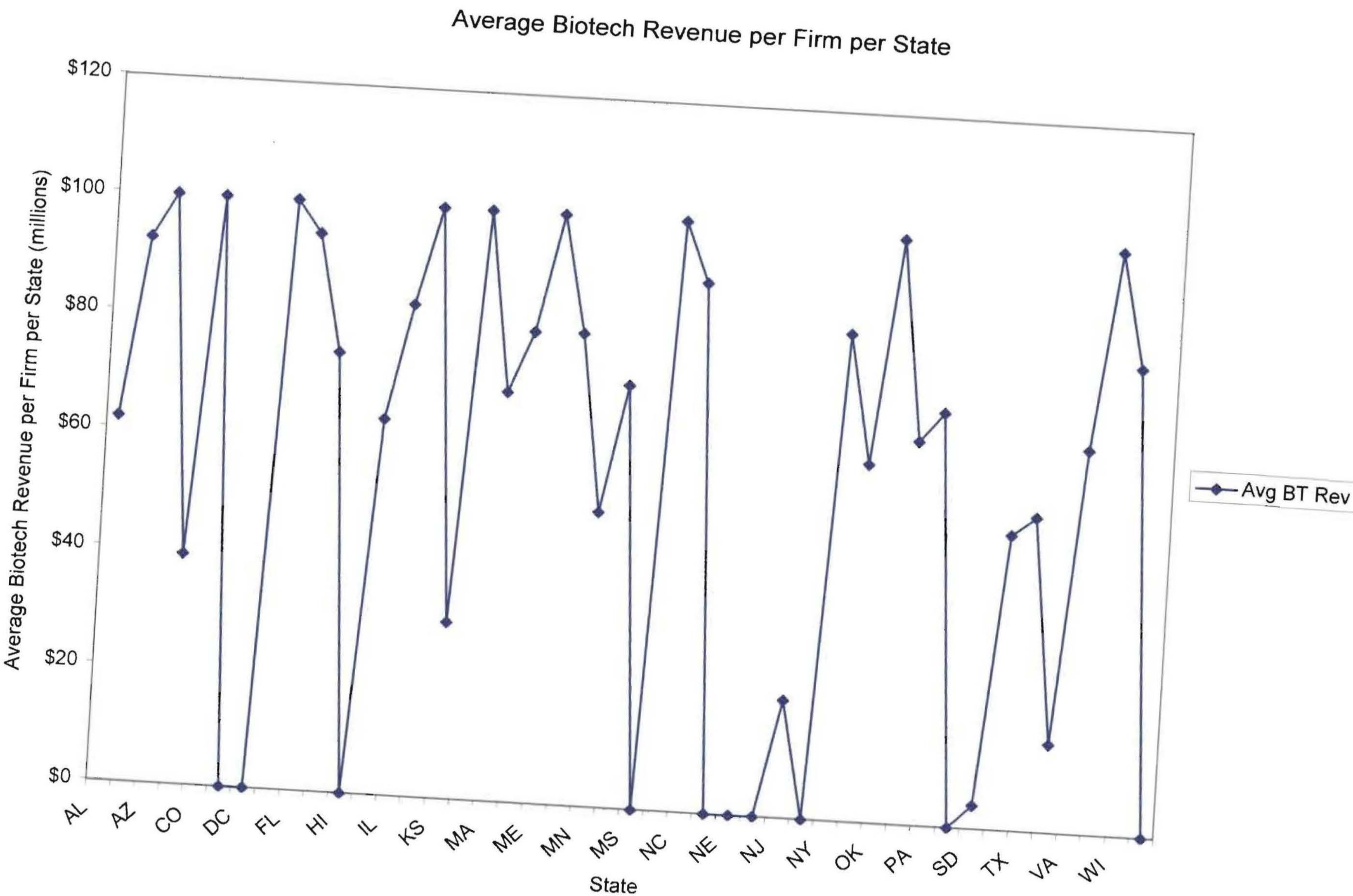
TABLE 4. GENERAL DATA FOR EACH STATE, continued

%cropland/farm: percent of cropland of total farmland
Crop output: amount of revenue for crops per state, in thousands $
Animal output: amount of revenue for animals per state, in thousands $
Serv/forest output: amount of revenue for services and forestry per state, in thousands $
Total output: total revenue for agricultural sector per state, in thousands $
Net farm income: net income for farms per state, in thousands $
GSP: Gross State Product, in millions $
Source: FedStats, 2000
Source: Bureau of Economic Analysis, 2000

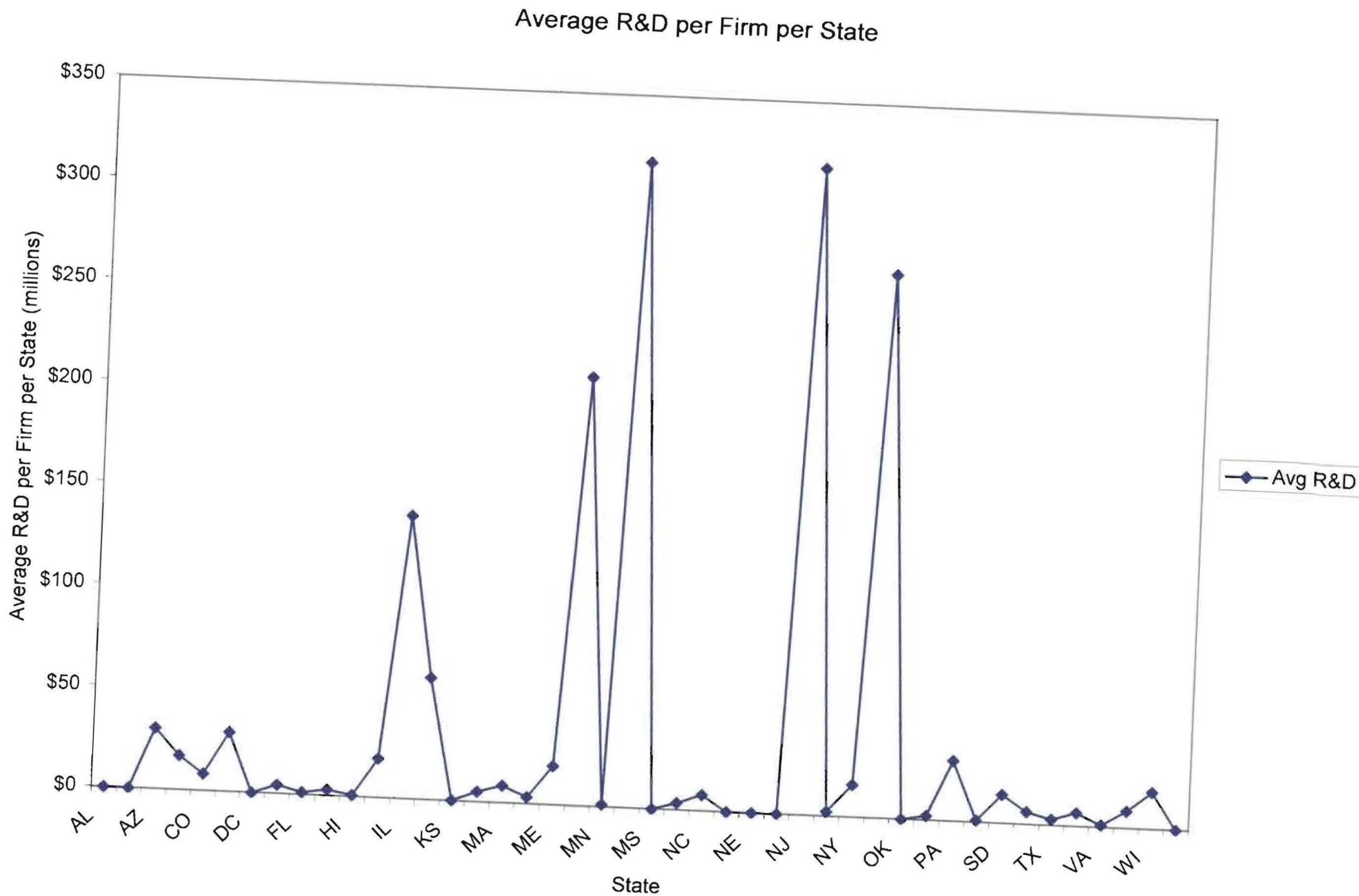


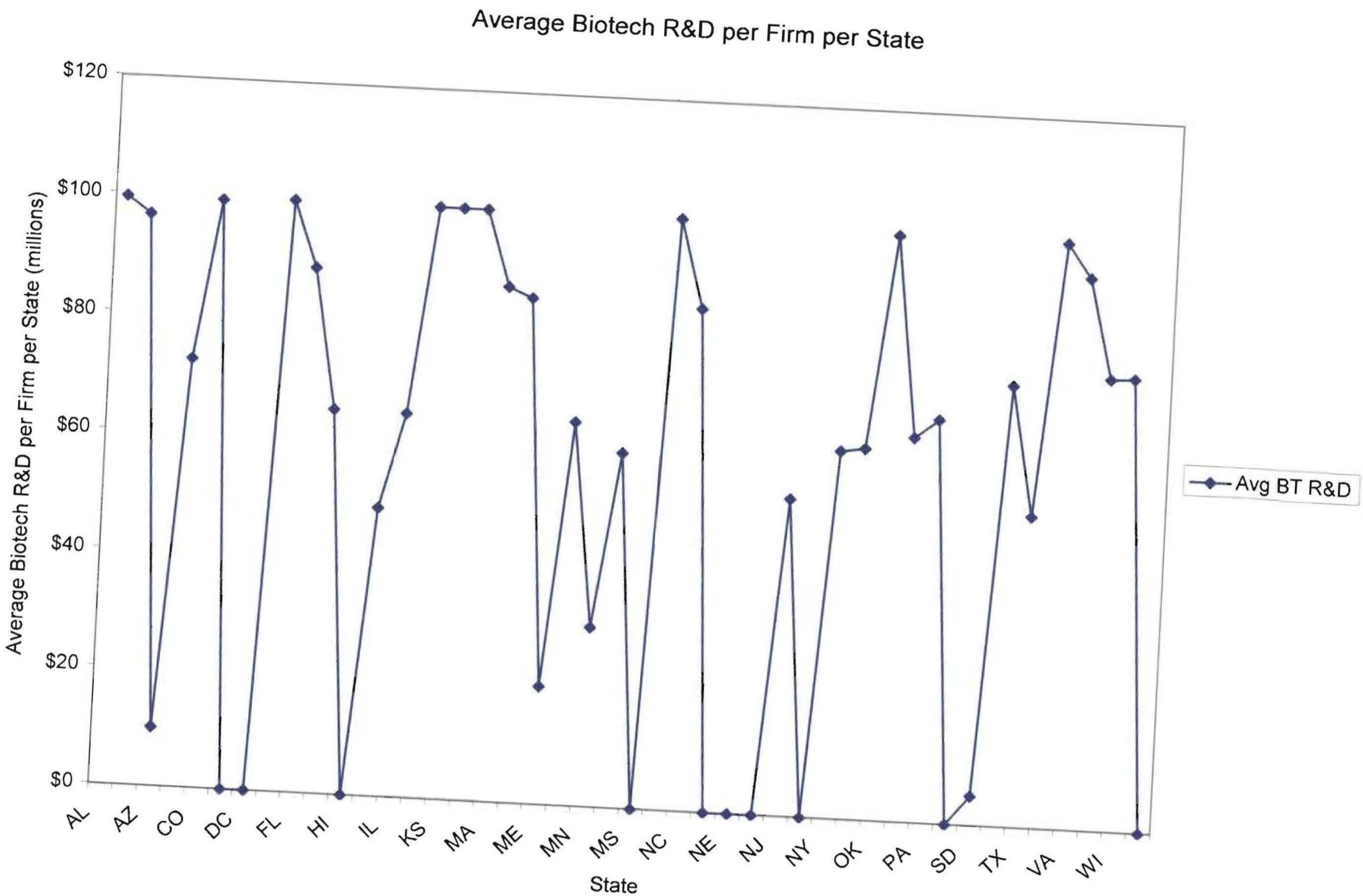
Average Biotech Employees per State
140
120
100
80
60
40
20
0
Average Biotech Employees per Firm per State
AL
AZ
CO
DC
FL
HI
IL
KS
MA
ME
MN
MS
NC
NE
NJ
NY
OK
PA
SD
TX
VA
WI
State
BT Emp

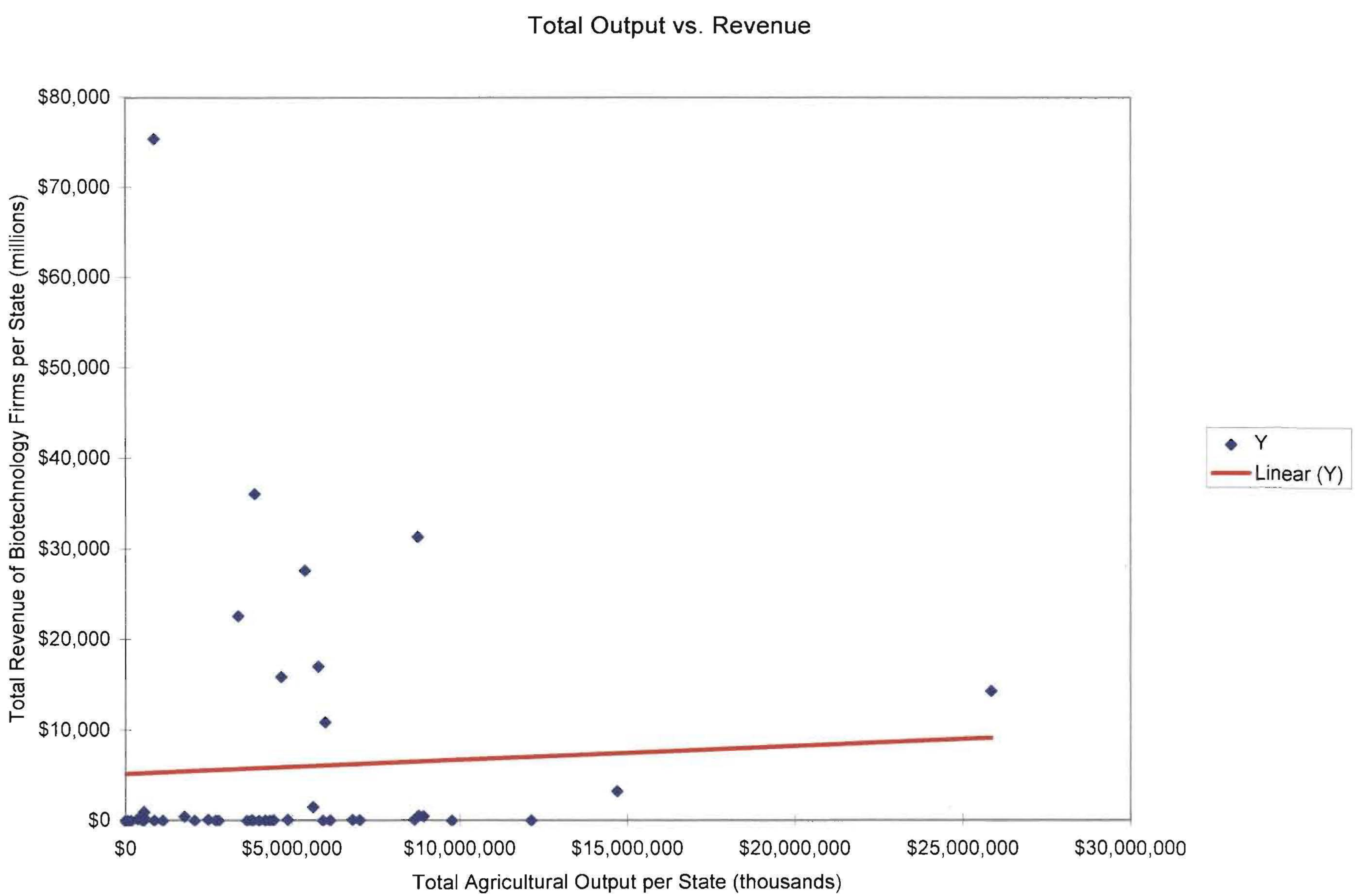

Average Revenue per Firm per State
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Average Revenue per Firm per State (millions)
AL
AZ
CO
DC
FL
HI
IL
KS
MA
ME
MN
MS
NC
NE
NJ
NY
OK
PA
SD
TX
VA
WI
State
Avg Rev

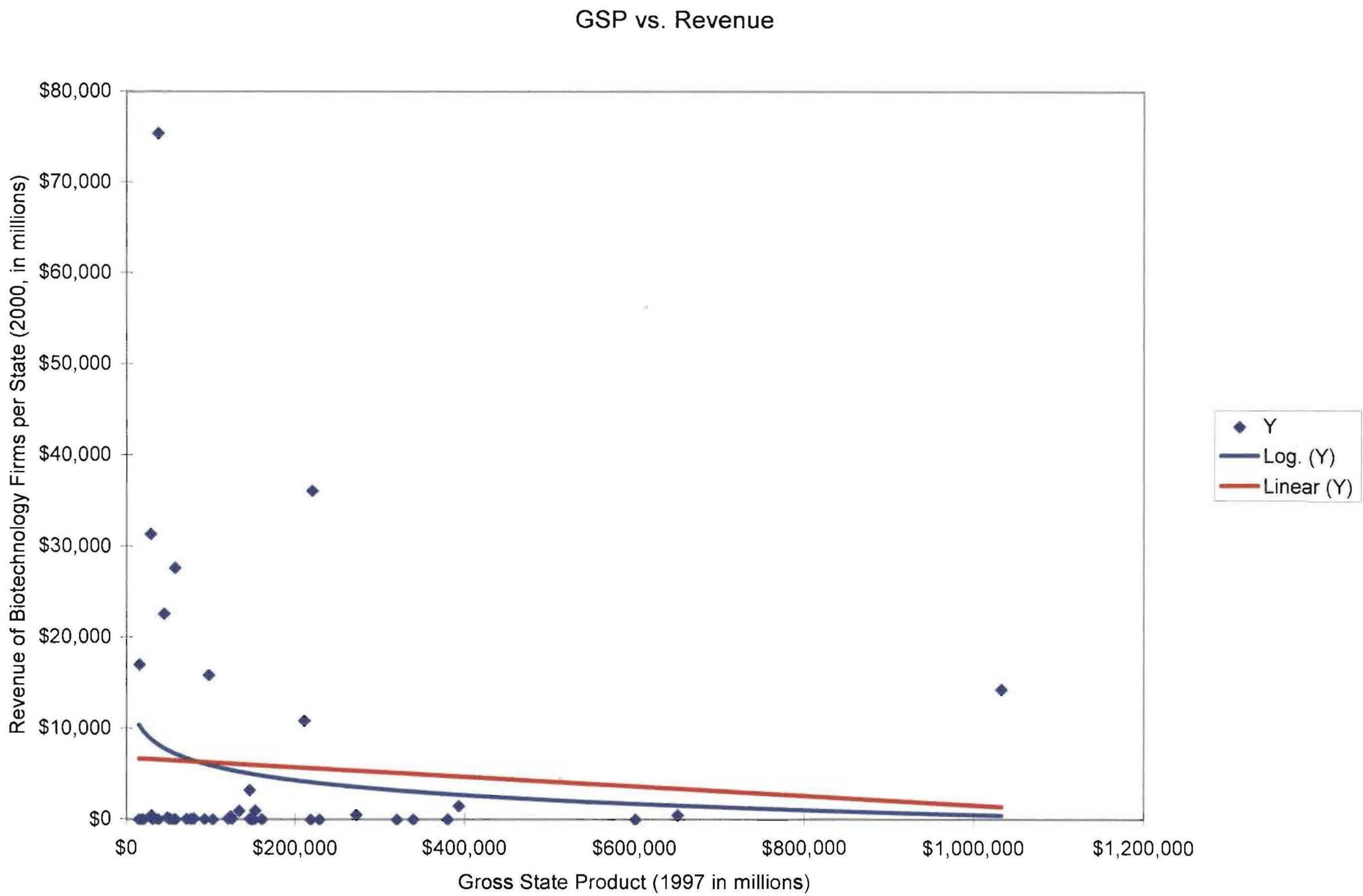


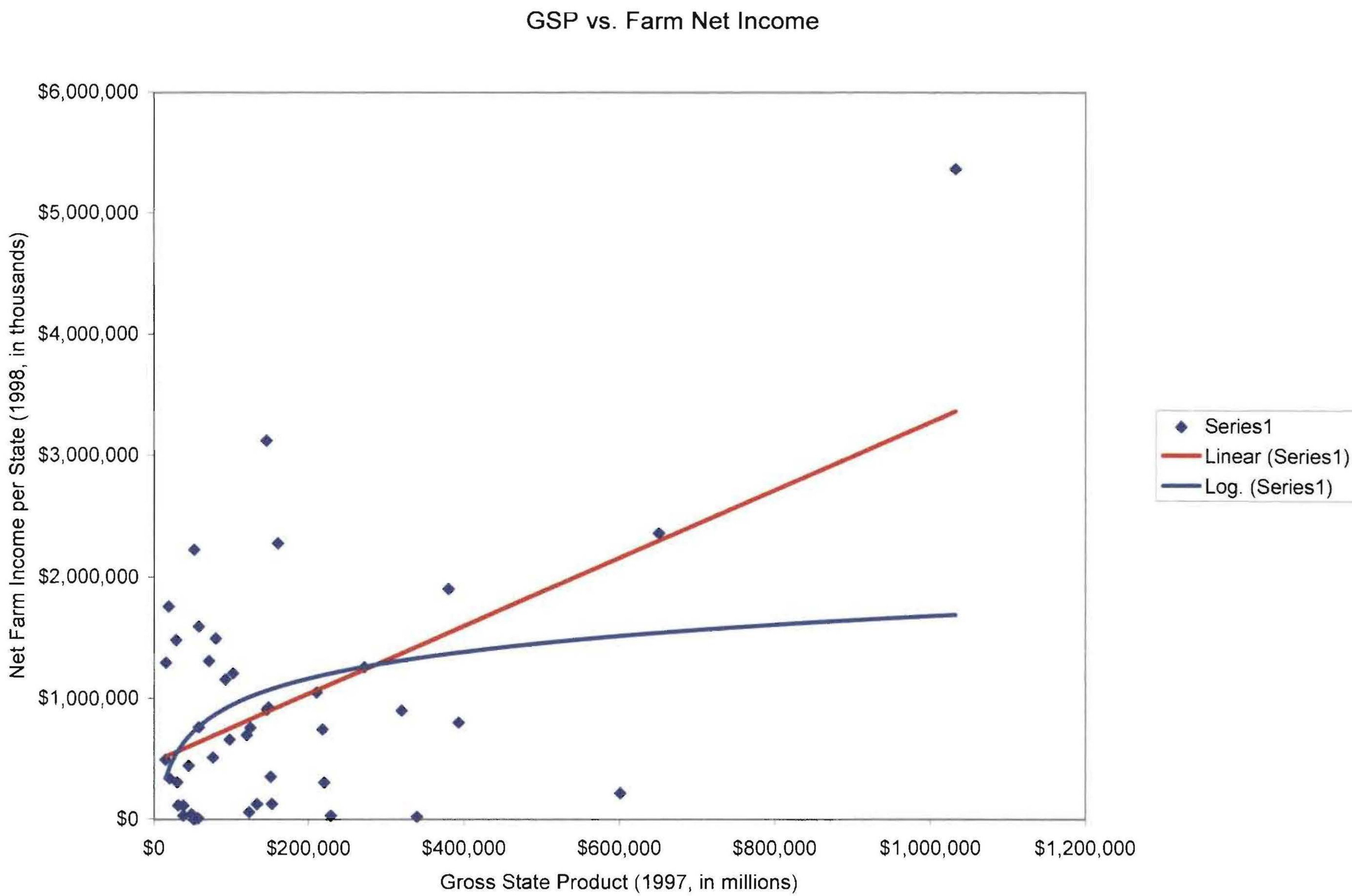
Average Biotech Revenue per Firm per State
Average Biotech Revenue per Firm per State (millions)
$120
$100
$80
$60
$40
$20
$0
AL
AZ
CO
DC
FL
HI
IL
KS
MA
ME
MN
MS
NC
NE
NJ
NY
OK
PA
SD
TX
VA
WI
State
Avg BT Rev

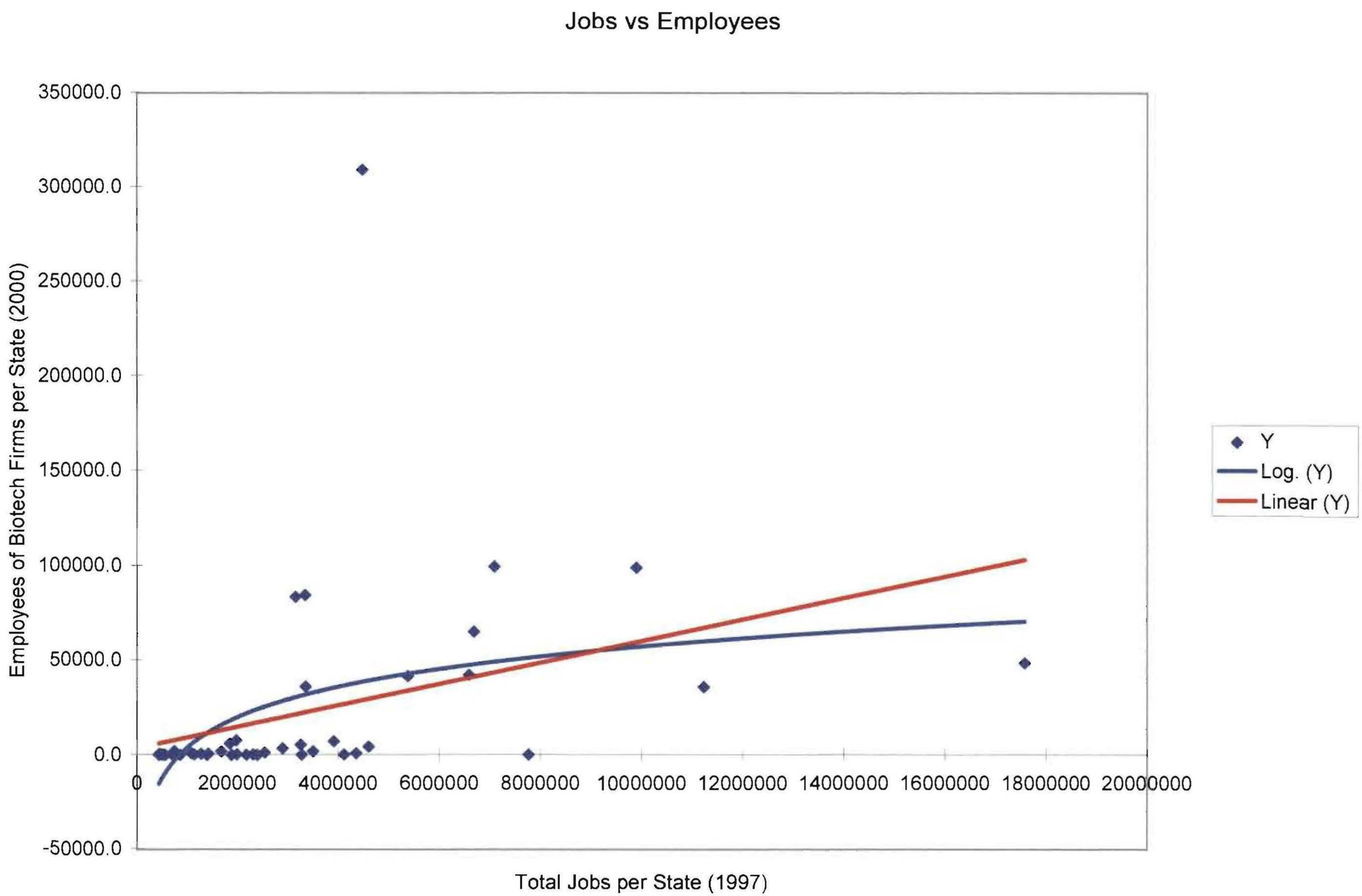

Average R&D per Firm per State
Average R&D per Firm per State (millions)
$350
$300
$250
$200
$150
$100
$50
$0
AL
AZ
CO
DC
FL
HI
IL
KS
MA
ME
MN
MS
NC
NE
NJ
NY
OK
PA
SD
TX
VA
WI
State
Avg R&D

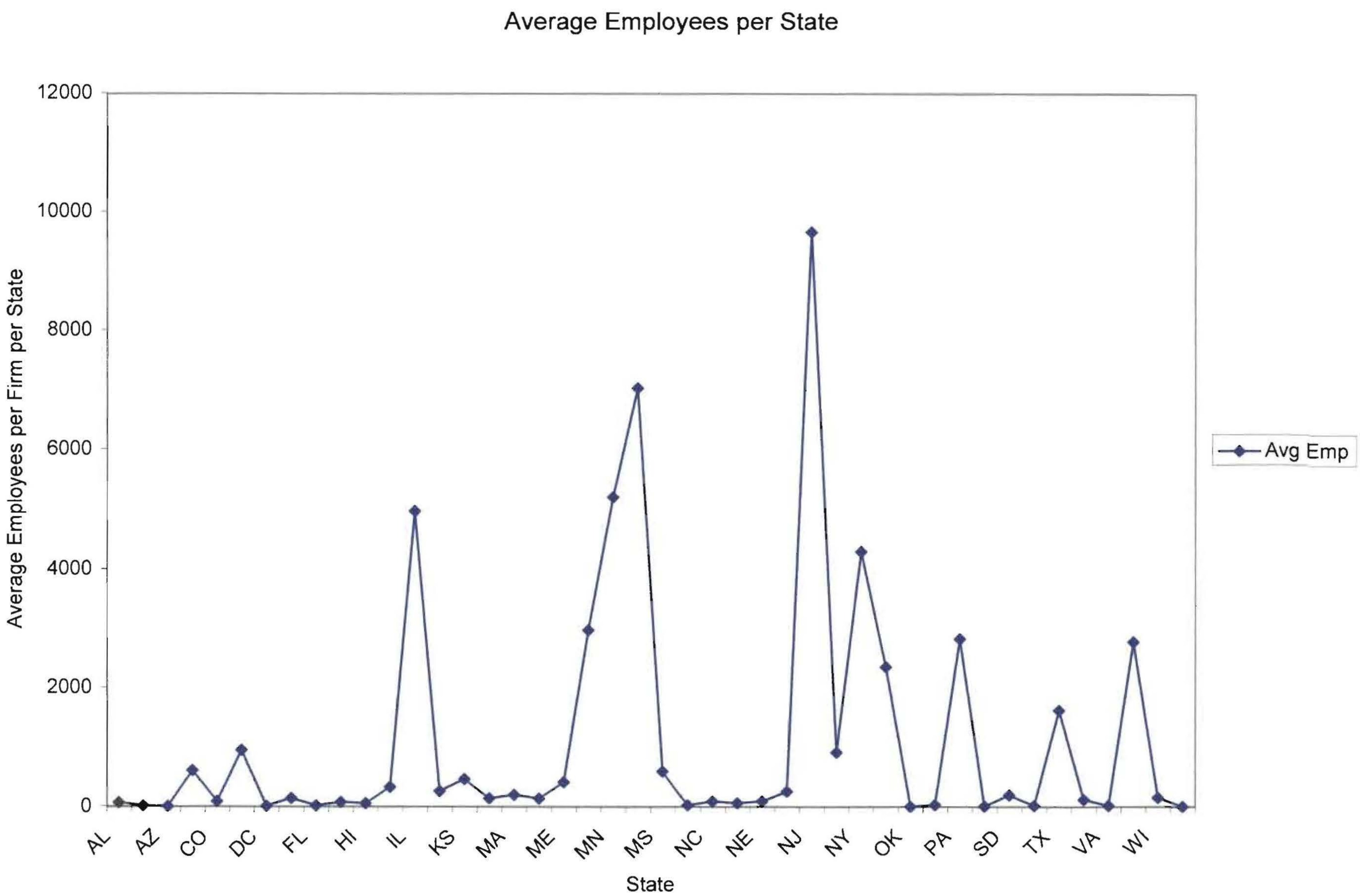

Average Biotech R&D per Firm per State
$120
$100
$80
$60
$40
$20
$0
Average Biotech R&D per Firm per State (millions)
AL
AZ
CO
DC
FL
HI
IL
KS
MA
ME
MN
MS
NC
NE
NJ
NY
OK
PA
SD
TX
VA
WI
State
Avg BT R&D

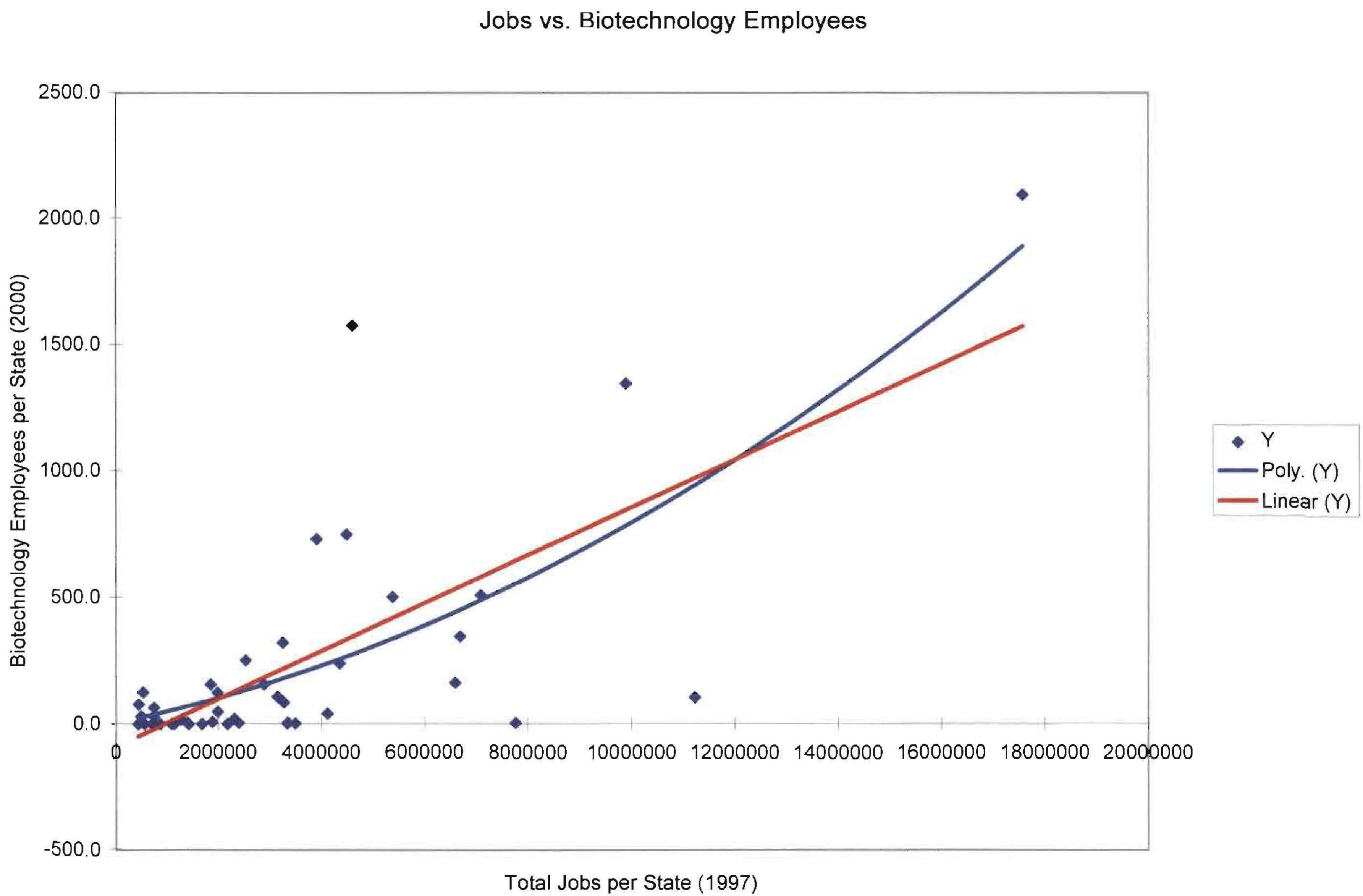

Total Output vs. Revenue
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
Total Revenue of Biotechnology Firms per State (millions)
$0
$5,000,000
$10,000,000
$15,000,000
$20,000,000
$25,000,000
$30,000,000
Total Agricultural Output per State (thousands)
Y
Linear (Y)

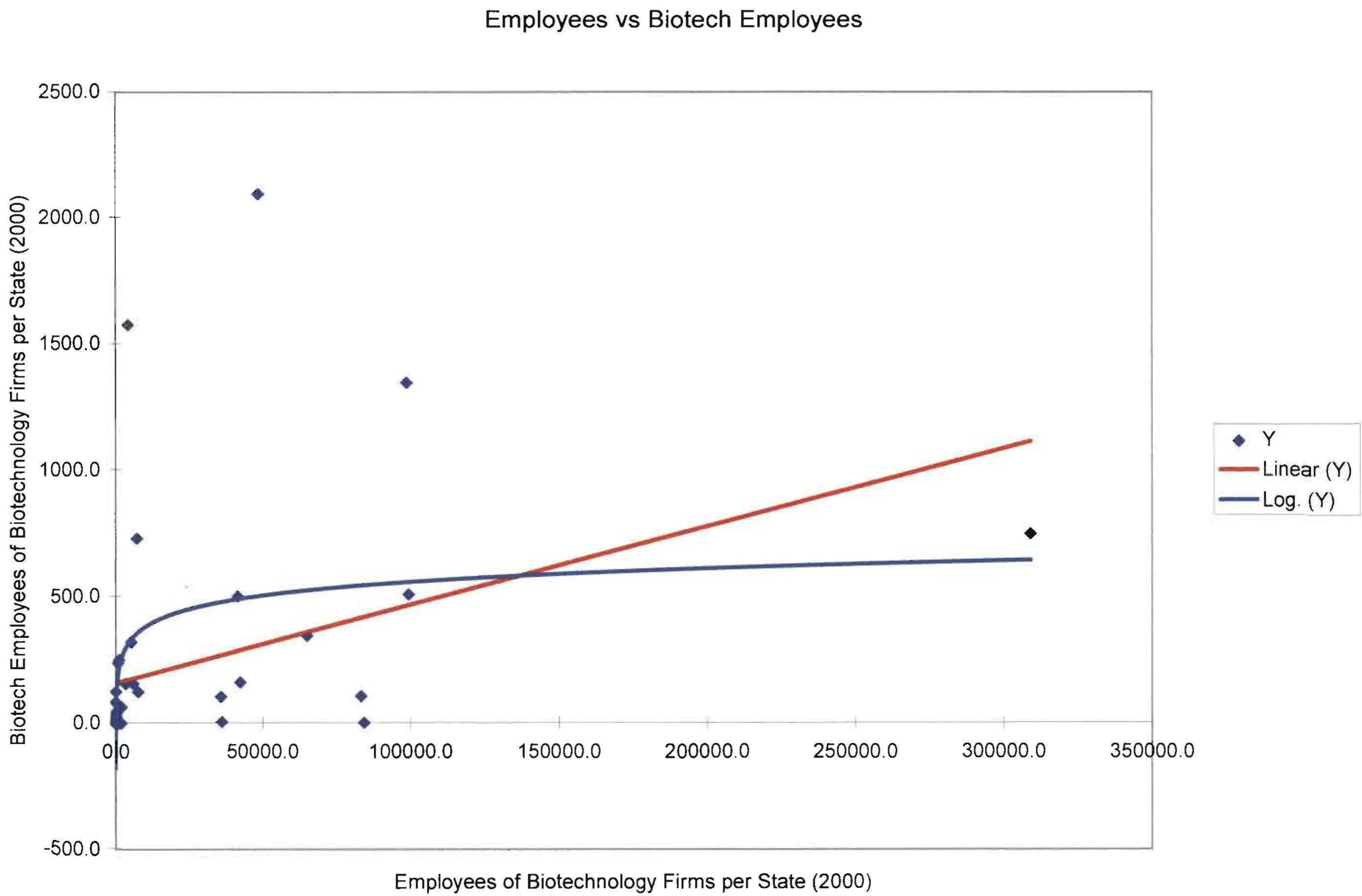

GSP vs. Revenue
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0
Revenue of Biotechnology Firms per State (2000, in millions)
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
$1,200,000
Gross State Product (1997 in millions)
Y
Log. (Y)
Linear (Y)


GSP vs. Farm Net Income
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
Net Farm Income per State (1998, in thousands)
$0
$200,000
$400,000
$600,000
$800,000
$1,000,000
$1,200,000
Gross State Product (1997, in millions)
Series1
Linear (Series1)
Log. (Series1)


Jobs vs Employees
350000.0
300000.0
250000.0
200000.0
150000.0
100000.0
50000.0
0.0
-50000.0
Employees of Biotech Firms per State (2000)
0
2000000
4000000
6000000
8000000
10000000
12000000
14000000
16000000
18000000
20000000
Total Jobs per State (1997)
Y
Log. (Y)
Linear (Y)


Average Employees per State
12000
10000
8000
6000
4000
2000
0
Average Employees per Firm per State
AL
AZ
CO
DC
FL
HI
IL
KS
MA
ME
MN
MS
NC
NE
NJ
NY
OK
PA
SD
TX
VA
WI
State
Avg Emp


Jobs vs. Biotechnology Employees
2500.0
2000.0
1500.0
1000.0
500.0
0.0
-500.0
0
2000000
4000000
6000000
8000000
10000000
12000000
14000000
16000000
18000000
20000000
Biotechnology Employees per State (2000)
Total Jobs per State (1997)
Y
Poly. (Y)
Linear (Y)



Employees vs Biotech Employees
2500.0
2000.0
1500.0
1000.0
500.0
0.0
-500.0
0.0
50000.0
100000.0
150000.0
200000.0
250000.0
300000.0
350000.0
Biotech Employees of Biotechnology Firms per State (2000)
Employees of Biotechnology Firms per State (2000)
Y
Linear (Y)
Log. (Y)